might easily have been derived from that occurring in *Truncatellina*; and the resemblance of the radula of this genus to the type found in *Punctum* should probably be regarded as due to convergence. The cusps of the teeth in two English specimens of *Columella edentula* were not observed to have the blackish colour that Dall states he found in some American examples.[1]

Summary.

A study of Dr. Boycott's preparations shows that the penis is very commonly entirely absent in *Vertigo pusilla*, Müll., *V. substriata* (Jeffr.), *V. alpestris*, Alder, *V. moulinsiana* (Dupuy), and *Truncatellina britannica*, Pilsbry, although it has been found in a few specimens of the last three species, as well as in *Vertigo pygmæa* (Drap.), *V. antivertigo* (Drap.), and *Columella edentula* (Drap.). The specimens without a penis are fully developed in other respects, with spermatozoa as well as ova in the hermaphrodite gland; the part of the vas deferens near the oviduct is usually present, but it ends blindly.

A classification of the British Vertigininæ based on the genital organs agrees well with that founded on the shell, although the radula of *V. moulinsiana* suggests that this species stands slightly apart from the other members of the genus *Vertigo*. The reproductive organs of *Truncatellina* differ in some respects from those of *Vertigo*, and the male organs (when present) resemble those of the genus *Columella*. No evidence has been found in support of Lehmann's statements that flagella occur in various species belonging to these three genera; on the other hand, Hanna's views about the simplicity of the male organs of *Columella edentula*, and the affinities of this animal with *Vertigo* rather than *Punctum*, are confirmed.

THE PRESENCE OF A SUB-CEREBRAL COMMISSURE IN THE ORTHURETHRA.

By Hugh Watson, M.A.

Read 11th May, 1923.

The cerebral nerve-ganglia might be termed the brainiest part of a mollusk, and the commissures that unite these two ganglia are structures of considerable importance. For if the chief nerve-centres on the right and left sides were not directly connected with each other, it is difficult to perceive how an animal could efficiently regulate its actions to achieve definite ends. To be double-minded is to be unstable in all one's ways.

It is well known that in the most primitive order of Gastropods, the Aspidobranchia, the cerebral ganglia are directly connected by two commissures, one passing above the buccal mass and the other

[1] *Proc. U.S. Nat. Mus.*, vol. xli, 1912, p. 372.

below it. The anterior end of the alimentary canal is thus surrounded by a cerebral nerve-ring, which in some of the more archaic genera recalls that found in the Amphineura. But the lower commissure is usually narrower than the upper one, and it tends to disappear in the higher Streptoneura; in fact, in the Pectinibranchia it is only known to occur in a very few of the most primitive members of the group.

In the Opisthobranchia it has been found that the cerebral ganglia are united by both upper and lower commissures, not only in primitive forms like *Actæon*, as shown by Bouvier, but also in numerous other genera belonging both to the Tectibranchia and to the Nudibranchia, as shown by Vayssière, Pelseneer, and others. But while the upper commissure, known simply as the cerebral commissure, is short and broad, the lower commissure, which is termed the sub-cerebral commissure, is long and very slender.[1]

Turning now to the Pulmonata, we find that, while the stout cerebral commissure is one of the most conspicuous parts of the nervous system, very few writers have been able to discover a sub-cerebral commissure, and some appear to doubt whether this lower commissure is ever present in the Stylommatophora (excluding the Ditremata). Fifty years ago, however, de Lacaze-Duthiers described what is probably the sub-cerebral commissure in *Limnæa*,[2] and later Amaudrut stated that it was present in *Achatina panthera* (Fér.), *Bulimus funki* (Nyst.), *Nanina cambodjiensis* (Reeve), and *Helix aspersa*, Müll., four members of the Stylommatophora, which, it will be noticed, not only come from four different continents, but belong to four different families.[3] In 1893 Plate showed that a sub-cerebral commissure occurs in the Onchidiidæ,[4] a fact subsequently confirmed by von Wissel and Stantschinsky; but it was not until 1917 that Kunze[5] and Bang[6] were able to announce the discovery of this slender commissure in *Helix pomatia*, Lin., notwithstanding the amount of work that had already been done on the anatomy of this well-known species. I have myself been able not only to confirm the existence of a sub-cerebral commissure in *Helix aspersa* and in the Onchidiidæ, but also to report its presence in more than one species of *Apera*,[7] in *Natalina quekettiana* (M. & P.),[8] in *Helicarion*

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[1] See, for example, Vayssière, *Mollusques de la France*, vol. i, 1913, pl. xvi, where is figured the central nervous system of four representative Opisthobranchs.

[2] *Arch. de Zool. Expér. et Genér.*, vol. i, 1872, p. 453, pl. xvii, figs. 3, 4; pl. xviii, fig. 8.

[3] *Bull. Soc. Philom. de Paris*, ser. VII, vol. x, 1885, p. 107; *Ann. Nat. Sci., Zool.*, ser. VIII, vol. vii, 1898, p. 127.

[4] *Zool. Jahrb.* (*Anat. u. Ontog.*), vol. vii, p. 150, pl. xii, fig. 85.

[5] *Zool. Anz.*, vol. xlviii, p. 234.

[6] Ibid., p. 284, and fig. 1 (p. 282).

[7] *Ann. Natal Mus.*, vol. iii, 1915, p. 137, fig. 2 (p. 152), pl. xv, figs. 73, 74.

[8] Ibid., p. 138.

(*Gymnarion*) *gomesianus* (Morelet),[1] and in *H.* (*Granularion*) *cryptophallus*, Watson.[2]

It is thus evident that a sub-cerebral commissure has now been found in at least six families of the Stylommatophora alone, namely, the Zonitidæ, the Helicidæ, the Acavidæ (subfamily Strophocheilinæ), the Achatinidæ, the Rhytididæ, and the Aperidæ. But it will be observed that all these families belong to the Sigmurethra. So far as I am aware, a sub-cerebral commissure has never been stated to occur in any member of the Orthurethra. This is remarkable, not only because of the large number of genera that belong to this division of the Stylommatophora, but also because the Orthurethra is supposed to be a rather more primitive group than the Sigmurethra, mainly on account of its excretory organs being more like the type found in the Basommatophora. It might, therefore, be inferred either that the Orthurethra is not really more primitive than the Sigmurethra, or that the sub-cerebral commissure found in the higher Pulmonates should not perhaps be regarded as a primitive structure, but might possibly have arisen by the anastomosis of a pair of cerebral nerves.

In view of these facts, it seems well to make known that I have lately discovered that a sub-cerebral commissure is present in at least three different genera belonging to the Orthurethra. I have found it in full-grown specimens of *Ena obscura* (Müll.), from the Gog Magog Hills near Cambridge, in an immature example of *Rachis punctata* (Anton), from Bombay, kindly sent to me by Col. Peile, and in a full-grown specimen of *Chondrina similis* (Brug.), from Alassio on the Italian Riviera, for which I am indebted to Major Connolly. That all these species are correctly assigned to the Orthurethra I have proved by an examination of their excretory organs.

In these species the sub-cerebral commissure does not exceed ·005 mm. in diameter, apart from the surrounding connective tissue; this is scarcely one-tenth of the diameter of the cerebral commissure, which, however, is not nearly so long. As in other Pulmonates, it arises from the outer and lower side of each cerebral ganglion, a short distance in front of the origin of the cerebro-pedal connective, and close to the origin of the cerebro-buccal connective. It passes round the œsophagus anterior to the cerebro-pedal and cerebro-pleural connectives, and in *Ena obscura* and *Chondrina similis*—and possibly also in *Rachis punctata*—it is attached for the greater part of its length to the front of the two lateral cephalic arteries. In the centre, where these arteries arise from the anterior aorta, the commissure passes straight across, underneath the lower end of the odontophoral or buccal artery, but in front of the origin of the pedal

[1] *Proc. Malac. Soc.*, vol. xiv, 1920, p. 94.
[2] Ibid., p. 99.

artery, a vessel which passes downwards between the sub-cerebral commissure and the broad and short anterior pedal commissure. To some of the arteries with which it is in contact the sub-cerebral commissure seems to give off one or two pairs of very slender nerves.

The sub-cerebral commissure is quite as well developed in these three species as in any of the sigmurethrous snails in which I have observed it, and it is probable that it will be found also in other orthurethrous forms. Indeed, I believe that I have seen it in *Pleurodiscus flavidus* (Rossm.) [= *Patulastra balmei* (P. & M.)] and in *Acanthinula aculeata* (Müll.), although I have not been successful in following it throughout its entire length in these species, and should not yet like to state definitely that it is present. It is very likely, however, that this slender commissure will be found to occur generally throughout the Orthurethra. Thus the evidence now before us would seem to point to the conclusion that in the Pulmonata there are normally five commissures passing beneath the alimentary canal, namely, the buccal commissure, the sub-cerebral commissure, the two pedal commissures, and the visceral commissure; but of these the narrow sub-cerebral is, of course, the only ventral commissure that unites the cerebral ganglia directly, without the intervention of any other ganglia.

SUMMARY.

A slender sub-cerebral commissure is now known to unite the cerebral ganglia beneath the alimentary canal not only in half-a-dozen families of sigmurethrous snails, but also in at least three orthurethrous genera, namely, *Ena*, *Rachis*, and *Chondrina*. It is probable that it is present also in other genera of the Orthurethra, and that there may normally be five ventral commissures in the Pulmonata.

THE ANATOMY AND GENERAL AFFINITIES OF *OCHTHEPHILA* (= *GEOMITRA*) *TURRICULA* (LOWE).

By HUGH WATSON, M.A.

Read 8th June, 1923.

PLATE VI.

(1) ANATOMICAL DESCRIPTION.

THE following account of the anatomy of *Ochthephila* (*Hystricella*) *turricula* (Lowe)[1]—otherwise known as *Geomitra turricula*[2]—is

[1] *Trans. Cambridge Philos. Soc.*, vol. iv, 1831, p. 58, pl. vi, fig. 21.

[2] In 1895 Pilsbry discarded the name *Ochthephila* Beck, 1837, in favour of *Geomitra* Swainson, 1840, because he thought that the former generic name was too like *Ochthiphila*, a name which Fallén had given to a genus of flies in 1823 (see *Man. Conch.*, ser. II, vol. ix, pp. 238, 239, 243). But Pilsbry wrote before the establishment of the International Rules for Zoological Nomenclature; and it is clear from the recommendations of Article 36 of this